Modeling Protocol
Regional Air Quality Modeling Study
Bonneville Power Administration

Background

More than 30 developers representing more than 40 projects have contacted the Bonneville Power Administration (BPA) regarding transmission services for new gas-fired combustion turbines. When and if BPA provides transmission to these generation units, BPA may be enabling these projects to be viable entities. If BPA enables a generation plant, the National Environmental Policy Act (NEPA) requires an evaluation of the environmental effects of both the generation unit and the ancillary transmission facilities required to integrate the plant. The generation and transmission are considered connected actions and the impacts of both must be considered jointly before BPA can make any decisions on acquisition or construction.

Impacts from generation and transmission carry both site specific and cumulative implications. Both must be examined. Single facility impacts to resources like air and water may not be so significant, but when considered together with similar impacts from other plants the cumulative effects may warrant appropriate mitigation actions, including the curtailment of site development. For example, the air emissions from one turbine may have slight impacts on an airshed but when combined with the emissions from several plants within the same airshed their cumulative impacts may prove to be considerable.

All past, present, and reasonably foreseeable actions potentially affecting relevant environmental resources need to be addressed in the cumulative impact analysis. BPA recognizes it is unlikely all plants that have applied for transmission integration will be built. However, BPA plans to consider all of them 'reasonably foreseeable' because, at this time, all of them are concrete proposals and we are unable to determine which plants will be built and which will not be built.

The primary environmental effects associated with combustion turbines are their emissions to the atmosphere. Other effects include land impacts from natural gas pipeline construction, water consumption by cooling towers, and site development. BPA believes the Business Plan EIS - (DOE/EIS-0183 (BPEIS)) will adequately cover many of these cumulative effects and will be adopted by reference. When necessary, site-specific impacts will be covered in site-specific NEPA analyses. Potential impacts on air quality are viewed as potentially more significant, especially regionally, and thus merit further consideration.

Objective

To analyze and disclose pertinent impacts to regional air quality from the combined emissions of all proposed combustion-related generation projects in Washington, Oregon and Idaho.

Introduction to Modeling Protocol

MFG, Inc. (MFG) prepared this modeling protocol to describe a regional modeling study to assess potential air quality impacts from proposed power projects within the BPA service area. More than forty new power projects in the Pacific Northwest, providing more than 25,000 MW of power have requested access to the transmission grid administered by BPA (See Table 1 and Figure1). To accommodate such an increase in capacity, BPA would need to expand the existing transmission network. As a federal agency, BPA must evaluate the environmental impacts under NEPA and address potential cumulative impacts of the proposed power projects and existing pollutant concentrations. This protocol will present a regional modeling approach designed to assess cumulative air quality impacts from the proposed power projects.

Air quality issues assessed by the regional modeling study. Washington State Department of Ecology (Ecology) hosted a Workshop on Evaluating Cumulative Impacts on November 14, 2000 where regional air quality issues associated with proposed power projects within BPA's service area were discussed. Topics discussed at the Workshop included the need for a cumulative assessment, air quality issues of concern to the Federal Land Managers (FLMs), and regional modeling methodologies. As discussed at the Workshop, many of the important air quality issues can be examined by focusing the analysis on the potential combined impacts associated with just the proposed power projects. For the purposes of the NEPA review, the regional modeling study described in this protocol would address the following:

- The effect of power plant emissions of PM_{10}, oxides of nitrogen (NOx), and sulfur dioxide (SO2) on regional pollutant concentrations and compliance with the National Ambient Air Quality Standards (NAAQS). Predicted concentrations attributable to proposed power projects would be added to the existing (background) concentrations to assess cumulative pollutant concentrations.

- The effect of power plant emissions on Prevention of Significant Deterioration (PSD) Class I and Class II increments. The study would investigate criteria pollutant concentrations attributable to proposed power plants on a regional scale. MFG would identify areas where predicted concentrations are above the PSD Significant Impact Levels (SILs) and increments.

- Visibility degradation in the Class I areas. The modeling analysis would characterize existing "clean day" visibility conditions based on IMPROVE monitoring data, and assess potential increased regional haze in the Class I areas caused by power plant emissions and secondary aerosols formed downwind from precursor emissions.

- Nitrogen and sulfur deposition in the Class I areas. The regional modeling study would provide predictions of annual deposition of power plant nitrogen and sulfur emissions from both wet and dry deposition processes. Deposition from proposed power plants would be added to existing deposition rates in Class I areas to evaluate total deposition impacts.

- This study will estimate CO_2 emissions from proposed power generating facilities but will not attempt to model them or assess the implications for global warming from those emissions.

Air quality issues NOT assessed by the regional modeling study

The study described in this protocol is extremely ambitious, and relies on computer resources and meteorological data that were not even available a few years ago. While it may be tempting to ask the study to provide more information than what is proposed, there is a practical limit to what may be achieved even with the advances of the last few years.

For example, this study will examine the regional effects of power plant emissions, and will not assess local impacts of a specific power plant at the same level of detail as an individual permit application would provide. Local impacts are best examined by reviewing the permit application or the evaluations conducted as part of the NEPA or State Environmental Policy Act review. The computational limits of assessing such a large region restrict the resolution of the predictions, and we have determined that a grid cell size of 12 kilometers is a reasonable and practical compromise. As noted in the protocol, a more refined examination using better resolution is proposed if predicted impacts exceed certain impact criteria.

This study will not address total PSD increment consumption in Washington, Oregon, or Idaho. While the study MFG is preparing for BPA will address increment consumption by emissions from proposed power plants, it will not include other sources of emissions (such as transportation, space heating, agricultural and silvicultural burning, existing increment consuming sources, etc.). A full, total increment consumption study would require an improvement in state emission inventories. Simply stated, the full set of increment consuming data is not available at this time. However, we acknowledge that the results of the modeling study described in this protocol may provide the initial basis for Class I area increment tracking.

Finally, this study will not address all pollutants emitted by power generation facilities that burn fossil fuels. This study focuses on emissions of PM_{10}, NO_x, and SO_2 because these are the pollutants of primary concern in Class I areas. All three pollutants contribute to visibility degradation, and both NO_x and SO_2 contribute to acid deposition. In addition, these are the three pollutants for which EPA has established Class I and Class II increments. Although other pollutants are emitted (such as certain toxic air pollutants), their impacts are generally local and addressed in site-specific permits. From the regional perspective we are taking in this study, we anticipate that cumulative effects in Class I areas will be more restrictive than compliance with ambient standards or toxic air pollutant criteria on a local level.

There is one exception to the general statement made in the preceding paragraph regarding the localized nature of most pollutants. Ozone is a criteria pollutant that is regional in nature. However, ozone will not be evaluated in this study because a comprehensive emission inventory is not available for the study domain that includes ozone precursors from existing sources.

We should also note that while the focus of this analysis is on PM10 emissions and concentrations, we anticipate that virtually all the PM10 is less than 2.5 microns, aerodynamic diameter. Thus, we believe that the primary and secondary aerosol concentrations that we predict (as PM10) may also be used to estimate PM2.5 concentrations.

Need for a protocol. MFG prepared a draft of this dispersion modeling protocol to allow BPA, Ecology, Oregon Department of Environmental Quality (DEQ), Idaho Department of Environmental Quality, and FLMs the opportunity to comment on the techniques we propose for the analysis. Dispersion modeling protocols are typically prepared for regional air quality modeling studies so technical issues can be discussed and consensus achieved prior to the study. The draft protocol was revised based on an extended telephone conference including state agencies, EPA, and the FLMs. The remainder of this revised protocol will discuss: an overview of the modeling approach, the preparation of meteorological data, long-range transport modeling issues, and the interpretation of model predictions.

Modeling Overview

MFG plans to apply the CALPUFF (Version 5.4) modeling system to evaluate regional air quality issues including pollutant deposition and regional haze. EPA and the FLMs recommend the CALPUFF modeling system in their *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts* and in *FLMs' Air Quality Related Values Workgroup (FLAG) Phase I Report*.[1,2] Features of the CALPUFF system include:

- a gaussian puff dispersion formulation: Plumes are treated as a series of gaussian puffs that move and disperse according to local conditions that vary in time and space

- three-dimensional meteorology: Wind and other meteorological variables are allowed to vary three-dimensionally

- wet and dry deposition mechanisms: Deposition processes are included for both particles and gaseous pollutants that depend on the characteristics of the pollutant, the local surface and meteorology. The model accounts for the mass removed from the plume when deposition occurs

- aerosol chemistry: Secondary aerosol formation is treated according to a first-order mechanism that depends on the time of day, relative humidity, meteorology, background ozone concentration, and background ammonia concentration

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1. EPA, NPS, USFS, USFWS, 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts. EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711, EPA-454/R-98-019.

2. USFS, NPS, USFWS, 2000. *Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Phase I Report*. Obtained from http://www2.nature.nps.gov/ard/flagfree/FLAG--FINAL.pdf, December 2000.

- post-processing specifically designed to assess regional haze: Visibility is characterized using extinction coefficients that vary with the concentrations of the aerosol species present, extinction characteristics of each aerosol species, and relative humidity

The most significant improvement to screening procedures or other modeling techniques based on a single meteorological site will be a more realistic treatment of regional meteorology. Wind regimes in the Northwest typically have complex three-dimensional qualities that can be important for assessments of regional air quality. Although the number of surface observation sites is gradually increasing in the Northwest, the stations tend to be located at airports, near populated areas and the network is not adequate to characterize flow within the region's more rugged terrain. The observational database also lacks sufficient upper air measurements to describe wind patterns aloft that can be important in transporting the buoyant turbines plumes to the Class I areas.

Winds based on the numerical model MM5. MFG believes a numerical model characterizes winds within the BPA service area better than objective methods solely based on the network of existing observations. The application of a numerical model with a spatial resolution sufficient to describe Pacific Northwest winds over an entire annual period requires large computer resources and an archive of such model results has not been available to previous regional assessments. An important component of this study will be incorporation of a new input meteorological data set from the University of Washington (UW) based on numerical simulations of Pacific Northwest weather with the MM5 model.[3] These data have been available since late 1997 and offer an improved means of characterizing the transport climatology of the Pacific Northwest.

For the purpose of regional air quality studies, Ecology has obtained a year of hourly MM5 simulations from the UW archives. Ecology has extracted and reformatted these data for use with the CALPUFF modeling system. Ecology's MM5 data set includes hourly regional model predictions for over 30 vertical levels on a model domain with a horizontal mesh size of 12 km.

Phased modeling approach. MFG plans to obtain a full year of model predictions within the study area using the MM5 meteorological data set and CALPUFF modeling system. We plan to follow the *IWAQM Phase 2 Recommendations* for a refined modeling analysis combined with the *FLAG Phase I Report* recommendations for assessments of both regional haze and other Air Quality Related Values (AQRVs). The modeling will be conducted in two phases:

Phase 1 - <u>Regional simulation of proposed power plant sources</u>. MFG will add the modeled predictions to the existing concentrations and compare the results against NAAQS, and Class I significance criteria provided by Ecology and the FLMs (Visibility impairment thresholds and deposition thresholds). MFG will also compare the model predictions - without background- to PSD increments and SILs. NAAQS violations or significant incremental contributions would trigger a Phase 2 assessment for the episodes identified.

3. The MM5 forecast effort is supported by a consortium of local and federal agencies consisting of the National Weather Service, UW, USFS, Port of Seattle, US Navy, EPA, Ecology, the Puget Sound Clean Air Agency, and the Washington State Department of Natural Resources.

Phase 2 - Examination of episodes above the significance criteria. When the significance criteria are exceeded, MFG will examine the meteorological conditions, calculate individual source contributions, and consider existing background concentrations in greater detail. This may include evaluating pollutant emissions from existing industrial sources in the area. During Phase 2, MFG may also perform additional simulations of the episodes using more refined characterizations of the sources.

In the following protocol sections we discuss the Phase I preparation of the meteorological data set, application of the CALPUFF model, and post-processing of CALPUFF predictions to assess regional haze, pollutant deposition, and significance criteria. We then identify techniques proposed for the Phase 2 assessment.

Step 1. Preparation of Meteorological Data and Application of CALMET

The CALPUFF modeling system is comprised of three major components: CALMET, CALPUFF, and CALPOST. This section of the protocol discusses data preparation and application of the system's meteorological component CALMET. CALMET will be used to combine the MM5 simulation data, surface observations, upper air observations, terrain elevations, and land use data into the format required by the dispersion modeling component CALPUFF. Winds are adjusted objectively using combinations of both observations and numerical model predictions according to options specified by the user. In addition to specifying the three-dimensional wind field, CALMET also estimates the boundary layer parameters used to characterize diffusion and deposition by the dispersion model.

MFG plans to use the MM5 simulations to the extent possible within the framework of the current CALPUFF modeling system. The UW applies MM5 prognostically providing real-time forecasts for the weather prediction community. MM5 is reinitialized every 12 hours and the hourly model archive consists of the forecasts for hour 12 to 24 after initialization. The current version of the system does not allow a direct interface between MM5 and CALPUFF, even though MM5 predicts most of the necessary meteorological variables. It is necessary to blend the MM5 data with surface and upper air observations using CALMET.

Emphasize MM5 winds. Evaluation studies conducted by the UW suggest MM5 predictions compare favorably with local observations using ensemble statistical measures, but predictions occasionally miss the timing of wind shifts and perform less well when observations and predictions are paired in time. Surface and upper air observations can be used to nudge the MM5 predictions to account for local scale effects not resolved by the model. However, observations are best used in this way when MM5 is run in a diagnostic mode where the observations implicitly influence the simulations. Our strategy will be to emphasize the MM5 winds and minimize the influence of the observations using the options available within CALMET. This should avoid unrealistic wind patterns caused by contradictions between the model and observations during periods when MM5 does not correctly predict the timing of frontal passages and other short-term events.

Model domain. MFG plans to conduct simulations using the model domain shown in Figure 2. The study area covers a 696-km by 672-km region of Washington, Oregon and Idaho. In order to interface with the MM5 model we have selected the same Lambert Conformal Coordinate (LCC) system used for the UW's simulations. This LCC system is centered in the Pacific Ocean at about 140W longitude and the conformal projection results in a grid north that is rotated about 12 degrees from true north in the center of our study area.

The study area does not include proposed power projects in Montana, northern California or southern Oregon. MFG proposes to focus the regional study on the cluster of projects in the Columbia River Basin and along the Interstate-5 corridor in western Washington. The proximity of these projects to one another suggests a greater potential for cumulative impacts than the more isolated power projects. Also the eastern boundary of the domain corresponds to the limit of the MM5 archive currently being processed by Ecology. Inclusion of the power projects in Montana would require Ecology to extract a different region from the UW's MM5 archives.

Grid mesh size. MFG suggests a 12-km mesh size be employed in the Phase 1 simulations where the grid points match the 12-km grid system being processed by Ecology. The UW also applies MM5 with a grid mesh size of 4 km and this domain has recently been expanded to include both Washington and Oregon. However, a full year of these data is not yet available, nor has Ecology processed these data for use with the CALPUFF modeling system. MFG plans to apply the objective procedures within CALMET using the 12-km MM5 solutions as an initial guess. These empirical procedures within CALPUFF attempt to account for terrain and land use unresolved by the MM5 simulations. During Phase 2 of the study, MFG will examine the sensitivity of the CALPUFF simulations for episodes of interest to grid mesh size and assess whether the selection of a smaller mesh size significantly affects the results of the simulations.

Process MM5 data. MFG will extract a subset of the MM5 archives from Ecology who have processed the UW output files with a post-processor called CALMM5. The resulting files can be input directly to the CALMET meteorological module. Based on our previous experience with the UW's MM5 archive obtained from Ecology, MFG will construct input files for the dispersion model using the simulations from April 1, 1998 to March 15, 1999. Although Ecology also has some data for March 1998, the archives during this period contain many days with missing simulations. Periods of missing data during March 1998 and in the data set as a whole are caused by MM5 model crashes or lack of the necessary initialization fields from the National Center of Environmental Prediction. Short periods of missing data of up to several hours will be filled through interpolation. Longer periods of missing simulations will be replaced by repeating the previous day or days of data.

Assemble surface weather data within the model domain. MFG will obtain hourly surface observations within the model domain during the annual study period from UW archives. The locations of surface stations in the UW archive are shown in Figure 3. As mentioned previously, during the meteorological data set construction MFG will select options to emphasize the MM5 winds versus the surface observation winds. The surface observations will be used in the construction of the input files for the CALPUFF modeling system to supplement the MM5 wind data, primarily by providing the variables necessary to calculate atmospheric stability class, mixed layer height, and variables affecting the chemistry and deposition mechanisms in the model. The task will include quality control checks of the data and conversion of the UW archive data into a format suitable for CALMET. Periods of missing or questionable surface observations will be replaced with invalid flags. When large portions of the model domain contain no valid surface observations, these periods will be filled in through interpolation at key stations, or for longer periods, by assuming persistence using the previous day's data.

MM5 data for soundings. The CALMET module also requires twice daily sounding data. Since winds aloft will be provided through use of the MM5 archive, the soundings would primarily be used for temperature lapse rate information. Available upper air stations at Quillayute, Salem, Spokane, Boise, and Kelowna, BC are located within or on the periphery of the study area. In previous studies MFG has used these data, but found many periods of missing data during the period of interest. The required sounding data are also predicted by MM5 and are included in the archives, but the current version of CALMET cannot use these data directly. Instead of using the observed sounding data, MFG will extract predicted profiles from the MM5 archives at selected grid points and construct "pseudo" upper air stations.

Precipitation data. Hourly precipitation data are used by the CALPUFF modeling system for estimates of wet deposition. Traditionally, such data are obtained from a network of surface stations and CALMET interpolates these data onto the grid. Stations with hourly precipitation in the study area tend to be located at low elevations and conventional interpolation of these data will likely under estimate precipitation and wet deposition in the mountain regions. As an alternative, MFG plans to use the MM5 precipitation forecasts available at selected points on the 12-km grid. In general, precipitation forecasts from MM5 compare favorably with available observations.[4] As with the upper air soundings, we will extract these data from the MM5 archives and construct "pseudo" precipitation stations for input into the CALMET program.

Geophysical parameters. The CALPUFF modeling system requires land use and terrain data. These data are used by CALMET to adjust the wind field and affect the calculations performed by the CALPUFF dispersion model. Land use and terrain data will be obtained from the U.S. Geological Survey (USGS) from the 1:250,000 scale data sets on the Internet. The resolution of these land use and terrain data sets are 200 m and about 90 m, respectively. MFG will prepare these data sets using the pre-processing software provided with the CALPUFF modeling system. The resulting 12-km grids will be plotted, subjectively checked, and compared to the land use used by the UW for the MM5 simulations. In our experience it will be necessary to replace portions of the USGS land use grid as these data are somewhat dated and the grid contains small areas with missing values.

MFG is unaware of any USGS data on the Internet at the resolutions mentioned above for the British Columbia portion of the study area. Digital terrain data are available but would need to be converted to the format and map projection used by the USGS. As an alternative, MFG will use the 900 m resolution terrain data set included with the CALPUFF modeling system. We believe these data are sufficient to

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4. Colle, B.A., Mass, C.F., and K.J. Westrick. Evaluation of MM5 Precipitation Forecasts Over the Pacific Northwest During the 1997-1998 Cool Season. Presented at the Pacific Northwest Weather Workshop, Seattle, WA, February 26, 1999. Corresponding Author: BA. Colle, Dept. of Atmos. Sciences, Univ. of Washington, Seattle, WA, 98195.

resolve terrain for the 12-km mesh size simulations. Land use in British Columbia will be taken from the data set used by the UW in their MM5 simulations. MFG will subjectively convert the land use classes used by the UW to the USGS system.

Application of CALMET. CALMET will be applied using the data sets and methods described previously. Model options will follow the guidance contained in the *IWAQM Phase 2 Recommendations*. Weighting parameters will be selected to increase the influence of the MM5 winds versus the observations. CALMET will be applied with a 12-km grid mesh size and 10-vertical levels, ranging geometrically from the surface to 4000 m. A number of the resulting wind fields will be plotted and subjectively checked for signs of unreasonable behavior. Wind roses will be prepared from the CALMET predictions and compared to observations at stations close to the sites of the proposed power projects. Wind roses will also be prepared from grid points near the upper air sites to compare with observed winds aloft.

Step 2. Preparation of Data and Application of CALPUFF

Phase 1 of the regional air quality modeling analysis will include CALPUFF simulations of proposed power projects within the study domain using the year of CALMET generated meteorological fields discussed above. This section of the protocol describes the preparation of the input data necessary for the second module of the CALPUFF system, the dispersion model CALPUFF. These data include source characteristics, background ozone and ammonia data, model options, and receptor locations.

Source characterization. Appendix A identifies a letter and data request form that BPA will send the developers to solicit project emission and source characterization data. Table 2 shows typical emissions and Table 3 typical stack parameters based on the 248-MW Goldendale Energy Project, one of the most recent combined cycle projects permitted in the Pacific Northwest. The developers will be asked to provide similar information for their project sources. If the data necessary data for assessing building wake influence are not available, we propose to assume the power plant would employ a Good Engineering Practice (GEP) stack. In addition to queries related to PM_{10}, NOx, and SO2 emissions, BPA will also request an estimate of CO2 emissions.

Model Options. MFG will follow the *IWAQM Phase 2 Recommendations* for the application of CALPUFF. Some of the key options included in these recommendations are as follows:

- Pasquill-Gifford dispersion curves and other default dispersion options
- CALPUFF partial path treatment of terrain
- MESOPUFF-II daytime chemistry with default conversion rates at night
- default wet and dry deposition parameters for the particle and gaseous species

Ozone data. The reaction rates in the CALPUFF chemistry algorithms are influenced by background ozone data. MFG will collect hourly ozone data from stations located within or near the edge of the study area from Ecology, Oregon DEQ, the British Columbia Ministry of Environment, Lands and Parks, and from the stations operated by the National Park Service. MFG will obtain and process these data for use by CALPUFF. Many of these stations do not operate outside of the “ozone” season and it is still necessary to establish a background ozone concentration. MFG believes an ozone concentration of 40 ppb is conservative for most of the study region and seasons of the year when hourly data are not available.

Ammonia background value. The NOx chemistry in CALPUFF depends on the ammonia concentration. Ammonia is not explicitly simulated by CALPUFF and the user must select an appropriate background concentration.[5] The *IWAQM Phase 2 Recommendations* suggest typical ammonia concentrations are: 10 ppb for grasslands, 0.5 ppb for forests, and 1 ppb for arid lands during warmer weather. Since land use with the study domain is mixed, MFG suggests a conservative ammonia background concentration of 10 ppb for the modeling simulations. Such a conservative concentration ensures the conversion of NOx to ammonium nitrate is not ammonia limited unless high concentrations of competing sulfate are present.[6] This assumption may be revisited during the Phase 2 simulations.

Receptor locations. CALPUFF predictions will be obtained on the 12-km grid used for the CALMET meteorological fields with the same terrain elevations. Predictions within the Class I areas will be taken from the subset of grid points within the boundary of each area. For the smaller Class I areas, MFG will supplement the 12-km grid with discrete receptors. Terrain for these receptors will be based on interpolation for the same grid used in the CALMET simulations. In addition to the Class I areas, MFG will also extract predictions within the Columbia River Gorge National Scenic Area (CRGNSA) and the Mount Baker Wilderness to allow post-processing for visibility and acid deposition.

Step 3. Post-Processing with CALPOST

The third component of the CALPUFF modeling system is CALPOST and associated utilities. CALPOST post-processes the large hourly CALPUFF output files for the purpose of comparisons against frequency based concentration criteria with different averaging periods. Utility programs are also available for combining several CALPUFF simulations together, adjusting the combined concentrations taking into account the nonlinear chemical mechanisms in the model. CALPOST has the capability of performing calculations relevant to visibility assessments, including hourly relative humidity adjusted scattering coefficients. MFG will apply CALPOST to summarize the CALPUFF modeling results, including the contribution of the proposed power projects to the NAAQS, Class I and Class II increments, annual nitrogen deposition, annual sulfur deposition, and extinction coefficients.

Extinction Coefficients. MFG will post-process the CALPUFF output files to calculate extinction coefficients within the Class I areas and the CRGNSA. We plan to use the *IWAQM Phase 2*

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5. In the most recent version of the CALPUFF modeling system ammonia concentrations from separate simulations can be combined with the post-processing utility POSTUTIL. However, an ammonia emissions inventory that includes regional area sources is not currently available for simulation with the CALPUFF system.

6. At this time, MFG does not plan to include existing sources of sulfur dioxide in our simulations. This should result in conservative concentrations for nitrate in the particle phase, since we are neglecting the reduction in available ammonia that would be formed as ammonium sulfate.

Recommendations embodied in the most recent version of CALPOST. The general equation applied divides the extinction coefficient into two components as follows:

$$b_{ext} = b_{SN} f(RH) + b_{dry} \qquad (1)$$

where b_{ext} is the extinction coefficient (Mm^{-1}), *f(RH)* is the relative humidity adjustment factor, b_{SN} is the sulfate and nitrate or hygroscopic portion of the extinction coefficient (Mm^{-1}), and b_{dry} is the non-hygroscopic portion of the extinction coefficient (Mm^{-1}). The hygroscopic portions of the extinction budget will be calculated from the sulfate and nitrate concentrations predicted by CALPUFF according to:

$$b_{SN} = 3[(NH_4)_2SO_4 + NH_4NO_3] \qquad (2)$$

where the sulfate and nitrate concentrations have units ìg/m^3 and are converted for the change in molecular weight due to the assumed chemical form of the aerosol. The portion of the extinction coefficient that does not vary with humidity will be calculated from:

$$b_{dry} = 4[OC] + 1[Soil\ Mass] + 0.6[Coarse\ Mass] + 10[EC] + b_{Ray} \qquad (3)$$

where *[OC]* is the organic carbon portion of the $PM_{2.5}$, *[Soil Mass]* is the crustal portion of the $PM_{2.5}$, *[Coarse Mass]* is the portion of the mass between $PM_{2.5}$ and PM_{10}, *[EC]* is the elemental carbon (soot) portion of PM_{10}, and b_{Ray} is extinction due to Rayleigh scattering assumed to be 10 Mm^{-1}. Concentrations in Equation 3 also have units of ìg/m^3.

PM_{10} species. In order to apply the extinction coefficient equations described previously, the chemical composition and size distribution of the PM_{10} emitted must be assumed. For the regional haze assessment, MFG will divide the PM_{10} into components based on a recent paper by Corio and Sherwell.[7] Their study summarized stack test results from a number of combustion sources, including turbines fired by natural gas and oil. For example, Corio and Sherwell found filterable PM_{10} averaged 23 percent for gas-fired turbines. In the stack tests summarized by Corio and Sherwell, the condensable (non-filterable) fraction of the PM10 was further broken down into two components: organic and inorganic matter. Inorganic matter comprised 67 percent of the condensable fraction for gas-fired turbines.

MFG will assume the *[EC]* fraction of the PM_{10} is equivalent to the average filterable portion found by Corio and Sherwell. We will assume the remaining non-filterable organic component is organic carbon *[OC]* and the inorganic component is "generic $PM_{2.5}$" of unknown composition. For the latter, MFG will assume scattering efficiency properties equivalent to crustal material, the default used by CALPOST for fine particulate matter of unknown composition. For gas-fired turbines, these assumptions result in PM_{10} emissions being apportioned as 23 percent *[EC]*, 25 percent *[OC]*, and 52 percent with scattering properties equivalent to *[Soil Mass]*.

7. Corio, L.A., and J. Sherwell, 2000. In-Stack Condensable Matter Measurements and Issues. *J. Air & Waste Manage. Assoc.*, Vol 50, Feb. 2000, pp 207-218.

Background extinction. The specification of background extinction coefficients is an important component of the visibility analysis. FLM criteria for regional haze are based on predicted changes to background extinction using data collected from the days with better visibility. MFG will use background data for comparison with the contributions predicted for the proposed power project sources. For the purposes of the Phase 1 analysis, MFG proposes to use the hygroscopic and non-hygroscopic aerosol components of background extinction shown in Table 4 based on data provided by the USFS for the Class I areas, Mount Baker Wilderness and the CRGNSA. MFG understands the background data provided by the USFS in Table 4 are based on the average aerosol sampling data taken from the days with the best visibility (top five percent) in each season.[8] In the CALPUFF simulations such low background aerosol concentrations will be assumed for all hours of the year. Thus results of the regional haze analysis in the Phase 1 analysis will be conservative and likely overstate the actual influence of proposed power project emissions on regional visibility.

Air Quality Significance Criteria

MFG will apply a number of significance criteria to assess the cumulative impacts of proposed power projects on regional air quality. We have selected a set of criterion that can be used to test whether predicted total or incremental concentrations and incremental deposition fluxes are potentially significant and warrant further analysis. The incremental contributions of proposed power projects within the BPA service area would be assessed for the following:

- The contribution of power plant emissions to the NAAQS for PM_{10}, NO_2, and SO_2
- The contribution of power plant emissions to PSD increment consumption in Class I and Class II areas
- The effects of power plant emissions and secondary aerosols on regional haze in the Class I areas and the CRGNSA
- The effects of additional nitrogen and sulfur deposition in the Class I areas

NAAQS. Existing ambient air quality would be described based on ambient monitoring data. Where monitoring data are not available, conservative assumptions will be employed to estimate pollutant concentrations based on data from other locations. On a case-by-case basis, MFG may apply dispersion modeling to calculate concentrations attributable to large existing sources of air pollutants in areas with insufficient monitoring data. Modeling may also be used to account for large sources of air pollution that are permitted but not yet operating, or are otherwise not yet reflected in measured ambient concentrations.

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8. Note the data in Table 4 are more specific to Class I areas in the Pacific Northwest than the generic data listed in the *FLAG Phase I Report* for the western United States. Also based on guidance from the USFS, since the CRGNSA is not a Class I area, MFG will be using background extinction coefficients based on the aerosol data from the top 20 percent. Background data from the top five percent will be used for the Class I areas.

Predicted concentrations attributable to proposed power plants would be added to the baseline concentrations to estimate cumulative concentrations. It is important to recognize that this would only be an estimate, because predicted power plant concentrations would be obtained using a 12-km receptor grid and local impacts may not be resolved close to individual sources. Baseline concentrations using ambient monitoring data may be also extrapolated from some distance away and may not reflect local conditions. In addition to evaluating the total concentration against the NAAQS, the incremental increase in concentration would be characterized using EPA's SILs (see the more complete description of SILs in the following paragraph). Where predicted cumulative concentrations exceed the NAAQS, a Phase 2 assessment would be conducted.

Class II and Class I PSD increments. During new source review (the process in which new industrial sources of air pollution are permitted), SILs are often used in screening analyses to assess the significance of the concentration predictions for pollutants like NO_2, SO_2, and PM_{10}.[9] Predicted concentrations above the SILs trigger a more refined assessment or the consideration of background sources. MFG proposes to use SILs to assess the incremental impacts from the proposed power projects in the same way these criteria are used during new source review. The Class I increments, Class II increments, Class II SILs, and proposed Class I SILs are shown in Table 5. MFG will apply the criteria in Table 5 as follows:

- Concentration predictions less than the SILs are insignificant and no further increment analysis will be performed for these pollutants, averaging periods, and affected receptors. MFG will use the combined contribution from all the proposed power plants (not individual power plants) for purposes of comparison with the SILs

- Predicted concentrations above the SILs for receptors located in Nonattainment Areas or predicted concentrations above the Class I or Class II increments would indicate significant potential impacts from the proposed power projects. MFG would check these results during Phase 2 and further examine source contributions, meteorological conditions, and the characterization used to describe the sources identified

Regional haze. MFG will use the predicted change to the 24-hour average extinction coefficient as a visibility metric for regional haze in the Class I areas. For new source review, the FLMs recommend that a five percent change in extinction be used to indicate a "just perceptible" change to a landscape, triggering consideration of cumulative impacts if such an assessment has not already been performed. According to the *FLAG Phase I Report*, a 10 percent change in extinction coefficient from the "natural" background is considered a significant incremental impact and would be unacceptable to the FLMs without mitigation. MFG will calculate changes to the extinction budget according to the

9. It has been EPA's longstanding policy under the New Source Review and PSD programs to allow the use of Significant Impact Levels (SILs) to assess whether a proposed new or modified stationary source causes or contributes to a violation of the NAAQS or PSD Class II increments (40 CFR 51.165 (b)(2)). Sources with pollutant concentrations under the SILs are considered insignificant, whether or not background or other increment consuming sources affect the applicable pollutant concentration and averaging period of concern. Note that the use of the term "significant" impact level in the PSD program does not imply a "significant adverse impact" in a SEPA or NEPA sense, nor does it imply exceedances of ambient standards.

relationships described above using CALPUFF predictions for the proposed power projects and the background data listed in Table 4. If the maximum 24-hour change in extinction coefficient is above five percent, a Phase 2 assessment will be performed for the Class I area and episodes involved.

Nitrogen and sulfur deposition. The *FLAG Phase I Report* does not provide significance criteria for nitrogen or sulfur deposition to Class I areas. At Ecology's Workshop on Evaluating Cumulative Impacts, the USFS indicated total nitrogen and sulfur deposition exceeding 5 kilograms/hectare/year (kg/ha/yr) and 3 kg/ha/yr, respectively, are levels of concern to the USFS. Using guidance from Ecology for the Sumas 2 Generation Facility, MFG proposes to use significance criteria based on 0.1 percent of these USFS levels of concern. For Sumas 2, 0.1 percent was used as an indicator of some concern.

Annual gaseous and particle deposition from both wet and dry mechanisms will be obtained from the CALPUFF simulations and converted to total nitrogen and sulfur deposition for comparison with these significance thresholds. Predicted annual nitrogen and sulfur deposition from the proposed power projects above 0.005 kg/ha/yr and 0.003 kg/ha/yr, respectively, will trigger further review under Phase 2 of the protocol. Note, MFG has asked both the USFS and NPS to provide additional guidance concerning significance criteria for deposition fluxes and may change the criteria suggested in the protocol.

Phase 2 Analyses

MFG proposes to conduct more refined analyses for episodes with predictions above the significance criteria listed above. The scope of the analysis will depend on the criterion that was exceeded, the magnitude of the exceedance, and the number of times predictions are above the specified level. The first step will be identifying the sources and meteorological conditions responsible for predictions above the criteria. The wind fields for these episodes will be subjectively assessed to ensure that the MM5 driven CALMET predictions are consistent with the observations. A smaller grid mesh size and alternative CALMET options may be employed to test the sensitivity of the predictions to the techniques used to construct the wind field. Any simplifying assumptions concerning the characterization of the sources, such as lumping sources together will be relaxed and the episodes re-simulated with the more accurate description of the sources.

If our modeling assessment suggests 24-hour extinction coefficients change by five percent or more, frequency distributions will be prepared to further examine the occurrence of episodes above this criterion. Using the suggestions in the *FLAG Phase I Report*, MFG will identify all sources with contributions greater than 0.4 percent to these episodes. MFG will examine the context of these episodes with respect to season and concurrent weather to provide the FLMs and other interested parties with further information concerning the significance of these events.

In an analogous fashion, if predicted nitrogen and deposition fluxes are above the protocol's significance criteria, MFG will quantify the contributions of the sources responsible. We will also specify the influence of wet versus dry deposition processes and examine the sensitivities of various model input assumptions to the predictions. MFG will use the estimates of background deposition shown in Table 6 to assess cumulative annual deposition fluxes. MFG will add the CALPUFF predictions to these background estimates and assess whether total nitrogen and sulfur deposition exceed 5 kg/ha/yr and 3 kg/ha/yr, respectively.

Refined Analysis for the Eastern Columbia River Gorge. A cluster of proposed power projects is located near the eastern end of the Columbia River Gorge (Figure 1). MFG anticipates the results of the Phase 1 simulations will identify this region of the study domain for further analysis. A refined CALPUFF modeling analysis for this area is planned using a smaller mesh size and a smaller modeling domain. The simulations will evaluate potential cumulative impacts within this region and contributions to the CRGNSA. This area is also the location of a number of large existing power plants and sufficient ambient monitoring data are not available for several of the pollutants of concern. MFG anticipates the modeling analysis may include emissions from existing large points sources in the simulations for the characterization of existing pollutant concentrations and deposition fluxes.

Table 1. Proposed Large Power Projects within BPA Service Area

Project Location	MW
Idaho	
RATHDRUM a I	265
RATHDRUM a II	500
RATHDRUM a III	500
RATHDRUM a IV	310
RATHDRUM b	1300
Oregon	
BOARDMAN	260
CLATSKANIE	520
COBERG	265
HERMISTON	536
MADRAS,	1100
MCNARY	500
PORT WESTWARD	330-660
ST HELENS	170
TROUTDALE	1100
UMATILLA a	1000
UMATILLA b	581
Washington	
ALDERDALE	760
CENTRALIA	248
CHEHALIS	660
CHERRY POINT	700-1000
EVERETT	500
FERNDALE a	1300
FERNDALE b I	500
FERNDALE b II	500
FREDRICKSON II	249
GOLDENDALE	247
GRANT COUNTY	1300
HARVALUM SUBSTATION	180
LONGVIEW a I	245
LONGVIEW a II	100-200
LONGVIEW b I	245
MT VERNON	600
SATSOP I	630
SATSOP II	600
SATSOP III	600
STARBUCK	1200
SUMAS	660
TACOMA	1000
VANCOUVER a	100
VANCOUVER b	600
WALLULA	1300

Note: The projects and capacities listed above may change as applicants are surveyed concerning their projects. New projects may be added as they apply for transmission integration.

Figure 1

Proposed Large Thermal Projects within BPA Service Area (as of 4/12/01)

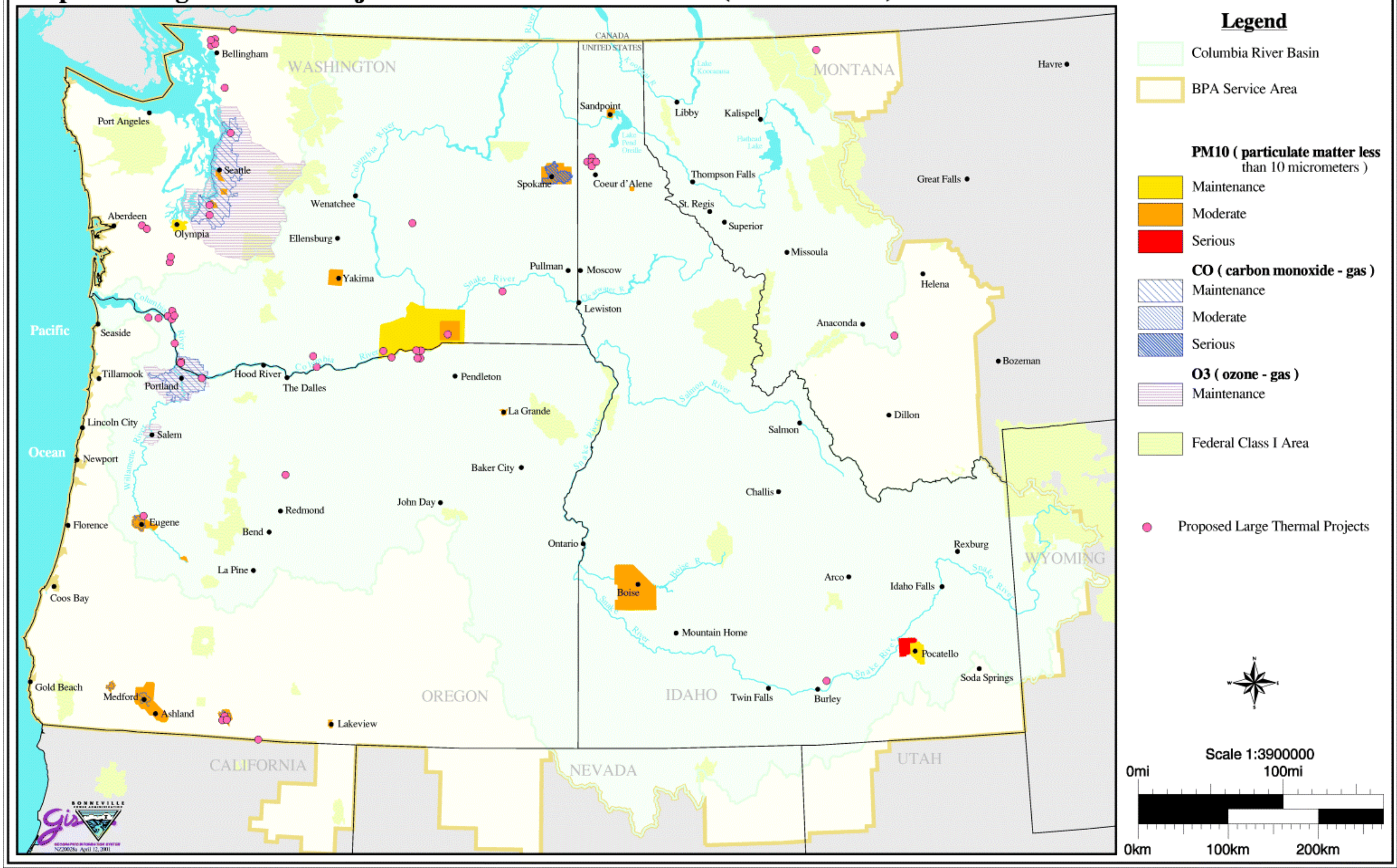

Figure 2

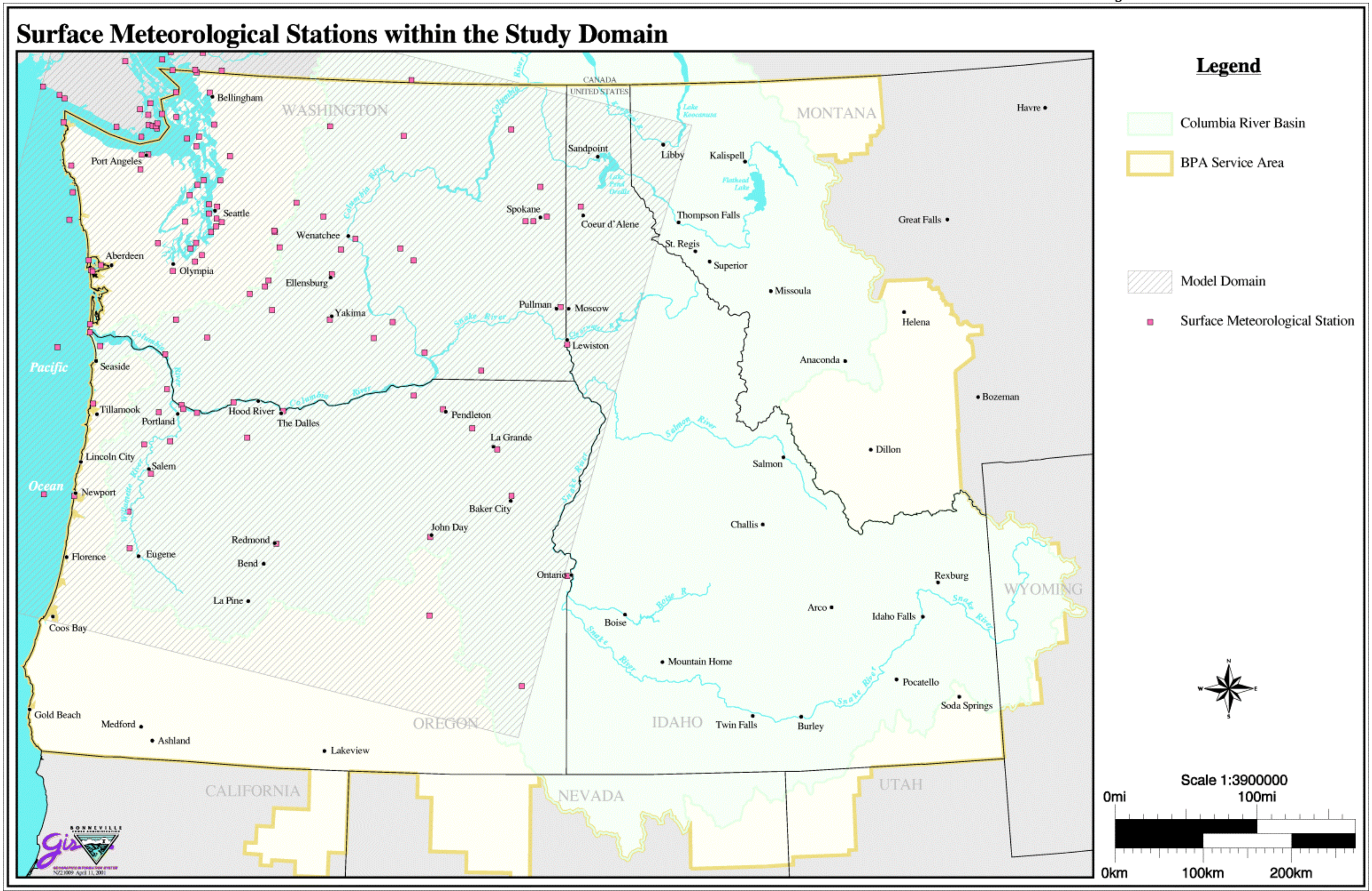
Surface Meteorological Stations within the Study Domain
Legend
Columbia River Basin
BPA Service Area
Model Domain
Surface Meteorological Station
Scale 1:3900000
0mi
100mi
0km
100km
200km
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
CALIFORNIA
NEVADA
UTAH
CANADA
UNITED STATES
Pacific
Ocean
Bellingham
Port Angeles
Seattle
Aberdeen
Olympia
Wenatchee
Ellensburg
Yakima
Spokane
Coeur d'Alene
Sandpoint
Libby
Kalispell
Thompson Falls
St. Regis
Superior
Missoula
Pullman
Moscow
Lewiston
Seaside
Tillamook
Portland
Hood River
The Dalles
Pendleton
La Grande
Lincoln City
Salem
Newport
Baker City
John Day
Redmond
Bend
Florence
Eugene
La Pine
Ontario
Coos Bay
Gold Beach
Medford
Ashland
Lakeview
Havre
Great Falls
Helena
Anaconda
Bozeman
Dillon
Salmon
Challis
Rexburg
Arco
Idaho Falls
Boise
Mountain Home
Pocatello
Soda Springs
Twin Falls
Burley

Table 2. Typical Emission Rates
248 MW Gas-Fired Turbine Project

Species Emitted	**Emission Rates (lb/hr)** **Peak Load with Duct Burner**
SO_2	1.0
Sulfate	< 0.05
NOx	14.9
Nitrate	< 0.05
PM_{10}	23.3

Table 3. Typical Stack Parameters
248 MW Gas-Fired Turbine Project

Variable	**Typical Value** **Peak Load with Duct Burner**
Stack Height (ft)	150
Stack Diameter (ft)	18
Exit Flow (acfm)	935,700
Exit Temperature (F)	180

Note: Stack parameters based on a site elevation of 1,600 ft, an ambient temperature of 110F, and a relative humidity of 30 percent.

Table 4. Seasonal Extinction Coefficients
For Class I Areas and Class II Areas of Interest

Area of Interest		Seasonal Non-Hygroscopic and Hygroscopic Extinction Extinction (Mm^{-1})			
		Autumn	Spring	Summer	Winter
Mt. Rainier National Park	b_{dry}	13.76	14.10	17.48	12.25
	b_{SN}	0.46	0.61	1.94	0.27
Alpine Lakes Wilderness	b_{dry}	13.40	13.36	15.11	13.05
	b_{SN}	0.65	0.93	2.93	0.47
Three Sisters Wilderness	b_{dry}	11.11	11.80	13.25	11.93
	b_{SN}	0.26	0.38	0.91	0.39
CRGNSA (Wishram) and Spokane Indian Reservation	b_{dry}	18.23	18.92	18.61	19.25
	b_{SN}	2.35	3.30	2.44	1.69
All other Class I Areas and Mount Baker Wilderness	b_{dry}	13.93	14.13	16.68	13.11
	b_{SN}	0.93	1.13	1.99	0.74

Note: b_{dry} refers to the non-hygroscopic portion of extinction and includes Rayleigh scattering of 10 Mm^{-1}. b_{SN} refers to the hygroscopic component.

Background coefficients provided by the USFS using aerosol data from days with the top five and twenty percent best visibility for Class I Areas and the CRGNSA, respectively.

Table 5. Significant Impact Levels
Class I and Class II Areas

Pollutant	Average Time	Class II Area Criteria (mg/m^3)		Class I Area Criteria (mg/m^3)	
		Increment	**SIL**	**Increment**	**SIL (a)**
NO_2	Annual	25	1.0	2.5	0.10
SO_2	3 hour	512	25.0	25.0	1.00
	24 hour	91	5.0	5.0	0.20
	Annual	20	1.0	2.0	0.10
PM_{10}	24 hour	30	5.0	8.0	0.30
	Annual	17	1.0	1.0	0.20

(a) EPA proposed Class I area Significant Impact Levels (Federal Register, Vol. 61, No. 142, page 38292).

Table 6. Pacific Northwest Class I Area Background Deposition Fluxes

Class I Area	Total Nitrogen Deposition (kg/ha/year)	Total Sulfur Deposition (kg/ha/year)
North Cascades National Park	4.0	3.5
Olympic National Park	2.0	5.6
Mt. Rainier National Park	2.4	3.1
Alpine Lakes Wilderness	5.2	7.2
Diamond Peak Wilderness	2.2	4.0
Eagle Cap Wilderness	1.6	1.6
Glacier Peak Wilderness	5.8	8.0
Goat Rocks Wilderness	9.0	11.8
Hells Canyon Wilderness	1.2	1.4
Mt Adams Wilderness	9.0	10.8
Mt. Hood Wilderness	5.4	8.6
Mt. Jefferson Wilderness	1.8	4.0
Pasayten Wilderness	5.2	7.2
Strawberry Mountain Wilderness	1.2	1.4
Spokane Indian Reservation	Unknown	Unknown
Three Sisters Wilderness	3.6	5.6

Note: Background deposition fluxes for USFS areas were developed using a scientific consensus process in a workshop in 1990.These data are considered to represent a conservative upper limit for these areas – they are not average values spatially or temporally. The deposition fluxes are reported in Table 11 in:

Peterson, J., and et al, 1992: *Guidelines for Evaluating Air Pollution Impacts on Class I Areas in the Pacific Northwest*. USDA Forest Service, General Technical Report PNW-GTR-299, May 1992.

Background deposition for USFS-managed wilderness areas is assumed to be double the high value reported in Table 11 to account for dry and occult (cloud and fog water) deposition. These flux estimates have not been adjusted since 1990, but the USFS considers these background estimates adequate as conservative guidelines

National Park Service data based on 1995-1999 National Acid Deposition Program annual average deposition values collected at Marblemount, Hoh Ranger Station, and Pack Forest monitoring sites.
For NPS areas, total background deposition is conservatively assumed to be double the measured wet deposition flux to account for additional dry and occult (cloud water) deposition processes.